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The Effects of Postpartum Recovery Exercise Program Comparing to Core Stabilization Exercise for Postpartum Women: A Pliot Study

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Objective: To investigate the impact of two distinct exercise programs on postpartum women's recovery, focusing on musculoskeletal parameters, spatio-temporal parameters, and body composition.

Design: A preliminary experiment involving three groups: Group 1 underwent a 16-week 5R system exercise program designed for postpartum recovery, Group 2 engaged in regular core stabilization exercises, and Group 3 served as the control, maintaining their daily activities without specific exercise.

Methods: 8 women within 5 weeks postpartum were randomly allocated into the three groups. Measurements included Inter-Recti Distance (IRD), muscle thickness using ultrasound, muscle strength, trunk flexibility, spatio-temporal parameters during walking, and body composition analysis. Exercise programs were tailored for postpartum recovery and conducted twice a week for 50 minutes per session over 16 weeks.

Results: Group 1 showed reductions in IRD at all measurement points, while muscle thickness varied across groups, indicating distinct muscle activation. Increases in muscle strength were observed across groups, but statistical significance was not reached. Group 1 exhibited improvements in lumbar lordosiswithout statistical significance, and spatio-temporal parameters showed slight changes post-exercise without statistical significance. Weight reduction were observed in exercise groups, while Group 3 displayed a minor weight increase, though statistically insignificant.

Conclusions: The exercise programs, particularly the 5R system, are expected to have a positive impact on postpartum musculoskeletal recovery. Improvements in IRD, muscle thickness, and trunk flexibility were observed, emphasizing the potential benefits of tailored exercise interventions. However, larger sample sizes and more targeted assessments are needed to validate these findings and determine the effectiveness of specific exercise programs in postpartum rehabilitation.

Key Words: Postpartum women, Postpartum period, Rehabilitation, Weight loss, Core stability

Introduction

The majority of postpartum women report some degree of musculoskeletal discomfort, with approximately 25% of them experiencing substantial musculoskeletal disorders. Common disabilities include diastasis recti (67%), lower back pain (30-50%), wrist pain (2-25%), as well as other issues like pelvic pain[1], patellofemoral dysfunction, pubic symphysis pain, breast engorgement, calf and foot pain.According to previous research, women experiencing pelvic girdle pain in late pregnancy and at six weeks postpartum exhibit greater perceived instability in their bodies compared to those without pain [2]. Furthermore, women with postpartum pelvic girdle pain and concurrent lower back pain demonstrated reduced trunk

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muscle strength, hip joint range of motion, and walking speed when compared to women without postpartum lower back pain [1]. Therefore, the prevention and relief of musculoskeletal pain in postpartum women carry considerable significance. Additionally, postpartum women may experience symptoms such as a decrease in the quality of life, anxiety, mood swings, tearfulness, loss of interest in life, inappropriate obsessive thoughts, hypersensitivity, guilt, reluctance towards breastfeeding, and fear of harming the baby due to postpartum depression[3]. Medication, such as antidepressants, for the treatment of postpartum depression is associated with long-term concerns about potential side effects. Therefore, guidelines for depression treatment recommend advising patients about the benefits of exercise[4]. In fact, regular exercise has been reported to have a positive impact on depression management, especially in postpartum women [5].

The exercise during pregnancy or postpartum often leans towards conservative methods, with many studies primarily recruiting postpartum women who have specific conditions related to postpartum complications. However, postpartum rehabilitation exercise is essential for the majority of women, irrespective of the presence of specific health conditions, as it is based on understanding the overall recovery process of postpartum women. This underscores the need for postpartum rehabilitation exercise programs tailored for different postpartum periods, informed by a holistic understanding of postpartum women's recovery.In the early postpartum stages, the presence of high concentrations of relaxin hormone can influence the potential impact of appropriate rehabilitation exercises on preventing subsequent changes in women's body shape and issues such as lower back pain and urinary incontinence. However, there is a limited body of research analyzing the effectiveness of initiating interventions from the early postpartum period.The 5R system is a postpartum recovery exercise program integrating five distinct stages: Recovery deformity with Rehabilitative Ultrasound Imaging (RUSI), Recovery posture, Recovery movement, and Recovery conditioning. This program offers tailored exercises based on the extent of recovery required, starting from immediately after childbirth and progressing through stages aligned with the recovery process. The initial phase focuses on rehabilitating deformities such as abdominal muscle separation and pubic symphysis using rehabilitative ultrasound imaging, providing visual feedback and regulating abdominal pressure for recovery. The second stage emphasizes correcting altered postures and maintaining optimal posture through coordinated movements of the core. The third phase aims at enhancing muscle strength, while the fourth stage involves whole-body functional improvement exercises aimed at calorie expenditure. This exercise program has already been widely implemented clinically at the M Center in Seoul, South Korea, and this study seeks to validate its effectiveness.

The connective tissue, referred to as the linea alba, responsible for assessing diastasis recti, serves as an indispensable structural element for maintaining the stability of the abdominal wall [6]. Given its role in controlling and facilitating the functions of the core musculature, it assumes even greater significance during the postpartum period. Notably, it exhibits a close association with conditions such as urinary incontinence, pelvic girdle pain, and lower back pain [7]. The occurrence of diastasis recti leads to a decrease in abdominal control, resulting in biomechanical constraints that become particularly pronounced during trunk flexion, rotation, and lateral bending [8]. The separation of abdominal muscles assumes a biomechanically disadvantageous position, impairing the ability to stabilize the pelvis [9]. Consequently, women face an elevated risk of developing lower back pain due to ligament laxity and the additional load imposed on the body [10].According to an 8-year longitudinal cohort study, factors such as depression, muscular, fascial, and tendon abnormalities, and pelvic pain have been identified as significant risk factors contributing to the development of lower back pain[11]. Women with fascial and tendon abnormalities were found to have a 4.5-fold higher risk of developing lower back pain compared to those without such abnormalities. Furthermore, women with diastasis recti had a significantly higher prevalence of lower back pain, ranging from 24% to 69%, compared to women without diastasis recti[12]. Therefore, diastasis recti and lower back pain demonstrate a close and interrelated association.Various exercises have been proposed as methods to alleviate musculoskeletal pain. In a meta-analysis of 34 experimental studies involving over 5,100 pregnant women experiencing lower back and pelvic pain, exercise was found to reduce pregnancy and childbirth-related lower back pain and improve functional disability by stabilizing the spine through strengthening the core and surrounding muscles [13]. Therefore, postpartum women may find recovery and relief from musculoskeletal symptoms through exercise.

Methods

Participants

The present study was conducted as a preliminary experiment involving 8 women within 5 weeks postpartum. Group 1 consisted of 2 individuals, Group 2 included 3 individuals, and Group 3 comprised 3 individuals, all randomly assigned. These participants were divided into three groups through random allocation. Inclusion criteria comprised women aged 20 to below 40 years, within 5 weeks postpartum, who underwent a natural delivery with singleton births. Exclusion criteria included individuals who experienced third or fourth-degree perineal tears after natural delivery, those with pelvic or abdominal surgeries including pubic symphysis diastasis, and women with specific gynecological conditions. Mothers or infants with serious illnesses, those who underwent cesarean section, individuals with neurological disorders, serious visual impairment, or Body Mass Index (BMI) equal to or greater than 30 kg/m^2 (indicating moderate to severe obesity) were also excluded.

Measurements

IRD and Muscle thickness: We utilized laptop-based software (Echo Wave II [X64] 4.2.0, TELEMED, Vilnius, Lithuania) in conjunction with ultrasound equipment (MicrUS-Duo EXT-1H, REV:C: TELEMED, Vilnius, Lithuania) to measure the IRD and muscle thickness. For the abdominal and gluteal regions, a convex probe was employed. Specifically, a 3.5 MHz convex-array transducer was utilized, set at 76 decibels (DB), to measure the thickness of the Rectus Abdominis (RA). Quadriceps muscle thickness measurements were conducted using a 10 MHz linear-array transducer set at 64 DB, employing a linear probe.To measure the IRD, ultrasound probes were positioned transversely at four distinct locations along the abdominal midline. These positions were identified as the upper and lower margins of the navel, 2.5 cm above the upper margin of the navel, and 2.5 cm below the lower margin of the navel. IRD measurements were taken at these four locations, and an on-screen caliper was utilized to measure the linear distance of the IRD from the medial border of the RA at these positions[14].And subjects were positioned lying down to measure the thickness of the Quadriceps[15]. During the Maximum Voluntary Contraction (MVC) measurement, a towel was placed behind the participant's knee while lying down, encouraging maximal contraction of the Quadricepsby extending the knee. The transducer was positioned 15cm above the superior border of the patella. Measurements of the Quadriceps were taken on the predominantly used leg of the participant. Thickness was calculated as the distance between the most superficial fascia of the muscle and the apex of the femoral cortex.In accordance with research suggesting the potential influence of respiratory cycles on variations in muscle thickness, measurements were taken during the expiratory phase. Adequate ultrasound gel was applied to minimize pressure between the transducer and the skin. Muscle measurements were conducted by a physiotherapist with extensive anatomical expertise, and ultrasound assessments were based on two repetitions each during relaxation and MVC, utilizing the average values obtained from these sessions.

Muscle strength: The MVC muscle strength for flexion and extension of the participants’ trunk, hip joint, and knee joint was measured using manual muscle tester (AP1110A-2, J-tech, United States). Trunk flexion was measured in a hook lying position in a supine position and the measurer applied resistance on the subject’s wrist crossed in front of the chest, and trunk extension was measured in a prone position with both legs on the bed. Knee flexion and extension were measured using the operator's resistance on the ankle in a sitting position[16], hip flexion was measured in a sitting position with resistance on the proximal part of quadriceps, and extension was measured in a prone position with resistance on the distal part of hamstring. MVC were performed for 3 seconds and three times and analyzed as the average value[17].

Trunk flexibility: The lumbar flexion and extension range of motion (ROM), and lordotic curve were measured using dual inclinometer (AP1110A-3, J-tech, United States). For all inclination angle measurements, the primary inclinometer was placed at T12 and the secondary inclinometer was placed on the sacral midpoint. When measuring the ROM of the trunk, the zero point was first set in the standing posture. Lumbar flexion was measured during bending the trunk forward as much as possible to reach the toes with the hand as far as possible with arms and legs extended in a standing posture. Lumbar extension was measured by placing the hands on the waist in a standing posture and leaning back as far as possible[18]. To measure the lordotic curve, two inclinometers were placed on the flat wall and the zero point was set. Before measuring the lordotic curve, 5 steps were taken in place. Afterwards, the lordotic curve was measured with the primary and secondary inclinometers were placed at T12 and the sacral midpoint while standing posture[19]. All measurements were analyzed as average values after three trials.

Spatio-temporal, kinematic parameters: The spatio temporal and kinematic parameters were measured using Inertial measurement unit (IMU) sensor (G-Walk, BTS Bioengineering, Italy) which is connected to a laptop computer via Bluetooth, with a recording sample frequency of 100Hz. This device reliability test showed excellent for the 95% confidence interval[20]. After wearing the IMU sensor on S1, participants walked naturally for 10m on flat ground for three times[21]. Speed, stride length of right and left leg, single support ratio of right and left leg, minimum, maximum and range of pelvic tilt motion, obliquity motion, rotation motion were measured through software G-Studio (BTS Bioengineering) wireless linked to the IMU sensor, and analyzed as the average value of second and third time’s.

Body composition: Inbody 770 device (Biospace Inc., Seoul, Republic of Korea) was used to analyze weight, BMI,andAbdominal fat percentage. All participants were required to remove socks, heavy clothing, metal objects, and shoes before measurement. Once the device was ready, the subjects held the electrodes with their hands at an angle of approximately 30° to their body while the measurements were performed. Participants pressed a button on the handle to complete the measurement while maintaining a fixed position for recording[22]. All data obtained once and were analyzed.

Exercise program

Group 1 engaged in the 5R System exercise program divided into four phases (Figure 1), specifically tailored for postpartum recovery for 16 weeks.The 5R system consists of effective exercises based on over 10 years of clinical experience and was provided by Moms Body Care (Figure 2). All exercises were overseen by trained physiotherapists.

Phase 1: Recovery deformity + RUSI focused on enhancing stability, emphasizing the recovery of the RA. During the initial stage (weeks 1 to 4), for women facing challenges in early outings, physiotherapists conducted one-on-one sessions at the participants' homes. During these sessions, therapists ensured

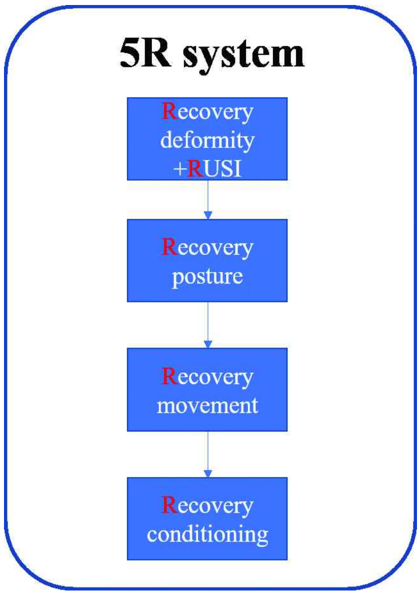

Figure 1. Flow chart of 5R system

Figure 2. Performing the 5R system exerise program

accurate muscle contractions and utilized RUSI to provide visual feedback to the participants[23]. The exercise program encompassed the following:1. Warm-up: Using a massage ball for pressure rolling on the chest, sides, and lower back.2. Abominal draw in maneuver (ADIM): Instructing the participant to draw the navel towards the spine without moving the waist and pelvis while maintaining comfortable breathingAt this time, dual-probe ultrasound was applied to provide visual feedback on both Transverse abdominis (TrA) muscles contraction (Figure 3). Participants visually confirmed their TrA muscles contraction via ultrasound imagery. The therapist used a dual probe-fixing frame to maintain the probe angle to match the skin surface and ensure verticality to provide optimal images without using the hands[23]. 3. Crunches: Lifting the head and upper body off the floor until the shoulder blades are raised, touching fingertips to knees, sustaining for 3-5 seconds.4. Pelvic Floor Muscle Contraction: Maintaining diaphragmatic breathing, contracting the pelvic floor muscles while gradually feeling abdominal pressure.5. Pelvic Hiking: Lying supine, feet against a wall, alternately lowering each foot while raising the pelvis.6. Adductor Muscle Exercise: Lying supine, using a gym ball or resistance band between knees, sustaining a consistent contraction for 3-5 seconds (isometric contraction).7. Clamshells: Opening the knees while lying down, exerting force

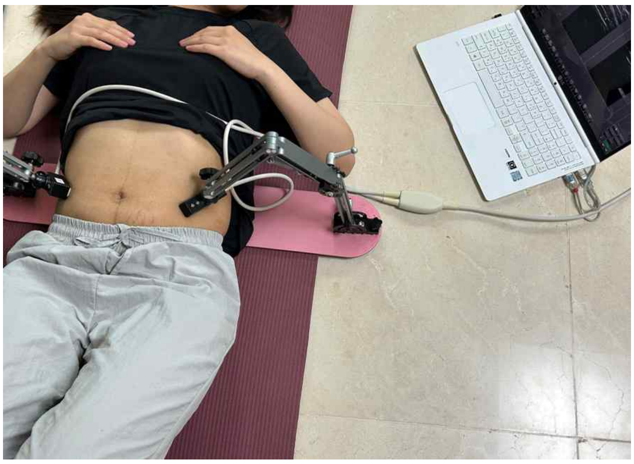

Figure 3. Phase1_ recovery deformity + RUSI. Transverse abdominis contraction exercise using visual feedback.

toward the hip area for 3-5 seconds with a focus on consistent force application (isotonic). 8. Cool-down: Walking in place to a metronome beat set at 100 beats per minute.

Phase 2: Recovery Posture. This phase conducted at the fitness center from weeks 5 to 8, aimed to promote optimal posture through core coordination. The exercises implemented during this phase included:Warm-up routines involving the use of a massage ball to apply pressure on the chest, sides, and lower back. Following this, participants utilized a resistance band secured below the sacrum for ADIM exercises and engaged in pelvic floor muscle contractions. Other exercises included leg raises on a gym ball, leg lifts while lying down, alternating leg raises, wall-assisted standing planks, pillow leg crossover movements, knee-supported planks, and concluded with a cool-down through stationary walking.

Phase 3: Recovery Movement. This phaseconducted from weeks 9 to 12, focused on enhancing strength to handle child-related activities and preventing injuries. This phase involved using weights 1kg heavier than the child's weight, ensuring precise form through coaching during movements. To progressively overload, intensity increased weekly. The exercises were as follows:Week 9: Hip hinge in a quadruped position, squat holding dumbbells on a chair, dumbbell-assisted split squats, pulling exercises, and knee-to-chest touches in place.Week 10: Hip hinge in a kneeling position, squat holding dumbbells, dumbbell-assisted step lunges, pulling exercises, and one-handed loaded carries.Week 11: Hip hinge in a standing position, single-leg squats, side lunges, pulling exercises, and overhead dumbbell loaded carries.Week 12: Hip hinge in a single-leg stance, single-leg squats, walking lunges, pulling exercises, and step-box exercises while holding dumbbells.

Phase 4: Recovery condition. This phase implemented from weeks 12 to 16, aimed to achieve comprehensive fitness goals, combining aerobic and strength exercises to enhance calorie expenditure and overall body functionality, thereby facilitating weight loss. The exercises included:Walking for 30 minutes, Single-leg balance for 10 seconds, Single-leg squats for 10 repetitions, running in place for 1 minute, Forward lunges for 10 repetitions, Jumping in place for 10 repetitions, Single-leg running man pose for 10 repetitionsSingle-leg calf raises for 20 repetitions, Single-leg glute bridges for 20 repetitions, Single-leg sit-to-stands for 20 repetitions, Side kicks for 20 repetitions.

Group 2 underwent a 16-week core stabilization exercise program (Figure 4). This core stabilization exercise program was developed based on previous research findings[24]. The exercise comprised: The first phase was designed as foundational exercises for core recovery. It involved full-body stretching using a

Figure 4. Performing the core stabilization exercise program

foam roller as warm-up, ADIM Allocation Device exercises, crunches, pelvic floor muscle contractions, scissor exercises, leg raises, and cooling down with full-body stretching using a foam roller, executed from weeks 1 to 8.The second phase focused on strengthening the core. It included foam roller stretching as warm-up, bilateral knee raises, supine extension bridges, straight leg rises from the prone position, alternate arm and leg raises from the quadruped position, plank exercises, and cooling down with foam roller stretching, conducted from weeks 9 to 16.Groups 1 and 2 engaged in their respective exercise programs, exercising twice a week for 50 minutes per session over a 16-week duration.

Statistical analysis

The SPSS ver. 12.0 program (SPSS Inc., Chicago, IL, USA) was used for data analysis. The mean and standard deviation of each group were obtained through descriptive analysis, and the Shapiro-Wilk test was performed to test normality. Wilcoxon signed rank test was used to compare differences in value between the pre and post test. The significance level was set to $p<0.05$.

Results

In Table 1, the general characteristics of the subjects were as follows: The average age of the participants was 31.38 years. Their average height was 160.9 cm and average weight averaged at 63.5 kg. Additionally, the BMI of the subjects was 24.48 kg/㎡. Table 2 presents the comparison of IRD and muscle thickness across the three groups. In all groups, post-intervention IRD distances decreased compared to the pre-intervention measures, with Group 1 exhibiting the most significant decrease. Additionally, RA thickness increased in all groups. However, TrA and Quadriceps muscle thickness increased in Groups 1 and 3 but decreased in Group 2. Gluteus maximus thickness at rest increased solely in Group 1, while the remaining groups showed a decrease. During contraction, gluteus maximus thickness increased in all groups.Table 3 displays the results of strength measurements using a dynamometer before and after exercise intervention among the participants. Strength in knee flexion, hip flexion, hip extension, trunk flexion, and trunk extension increased post-intervention compared to pre-intervention levels across all three groups. However, these increases were not statistically significant. The pre- and post-intervention measurements in the Table 4 for the standing lordotic curve, lumbar flexion ROM, and lumbar extension ROM were recorded for each group (G1, G2, and G3) after the 16-week exercise programs.

Table 5 presents the results of spatio-temporalparameters during walking. All three groups exhibited an increasing trend in stride length. Additionally, in pelvic Tilt range, Groups 2 and 3 showed an increase, while Group 1 decreased. Obliquity range decreased in all groups except Group 3, and Rotation range showed a decreasing trend in all three groups.Table 6 presents the body composition of the three groups.In all outcomes, there was no significant probability.

Discussion

This study compared three groups of postpartum women: Group 1 underwent the 5R system exercise, Group 2 performed core stabilization exercises, and Group 3 did not engage in any exercise but continued their daily activities. The 5R system exercise program,

Table 1. General characteristics of the patients (n=8)

Parameters	Values (SD)
Age (years)	31.38 (4.63)
Height (cm)	160.9 (3.96)
Weight (kg)	63.5 (9.13)
BMI (kg/㎡)	24.48 (3.07)

Values are presented as numbers or mean (SD), BMI: body mass index.

Table 2. IRD and Muscle Thickness

(mm)	Group	Pre (SD)	Post (SD)	p-value	(mm)	Group	Pre (SD)	Post (SD)	p-value
Upper margin	G1	1.83 (0.42)	1.10 (0.08)	0.180	Rt TrA rest	G1	0.22 (0.01)	0.29 (0.03)	0.180
	G2	1.43 (0.08)	1.10 (0.16)	0.109		G2	0.32 (0.11)	0.31 (0.12)	1.000
	G3	1.50 (0.26)	1.48 (0.31)	1.000		G3	0.21 (0.08)	0.30 (0.04)	0.109
Lower margin	G1	1.43 (0.46)	0.91 (0.05)	0.180	Rt. TrA con	G1	0.43 (0.13)	0.54 (0.07)	0.180
	G2	1.57 (0.11)	1.34 (0.29)	0.285		G2	0.57 (0.08)	0.55 (0.11)	0.285
	G3	1.57 (0.44)	1.44 (0.52)	0.593		G3	0.45 (0.05)	0.50 (0.06)	1.000
2.5cm upper margin	G1	1.76 (0.29)	0.87 (0.33)	0.180	Rt. Q rest	G1	2.21 (0.07)	2.81 (0.23)	0.180
	G2	1.34 (0.21)	1.01 (0.19)	0.285		G2	2.77 (0.95)	2.72 (0.72)	0.655
	G3	1.34 (0.37)	1.31 (0.36)	0.285		G3	2.35 (0.29)	3.25 (0.22)	0.109
2.5cm lower margin	G1	1.26 (0.47)	0.84 (0.28)	0.180	Rt. Q con	G1	2.89 (0.19)	3.44 (0.44)	0.180
	G2	1.08 (0.31)	0.76 (0.14)	0.109		G2	3.31 (1.01)	3.33 (0.74)	1.000
	G3	1.31 (0.57)	1.14 (0.84)	0.285		G3	3.10 (0.34)	3.78 (0.18)	0.109
Rt. RA rest	G1	0.59 (0.10)	0.67 (0.01)	0.317	Rt. G max rest	G1	1.09 (0.24)	1.14 (0.17)	0.180
	G2	1.04 (0.26)	1.07 (0.24)	1.000		G2	1.91 (0.26)	1.76 (0.11)	0.593
	G3	0.83 (0.07)	0.93 (0.13)	0.285		G3	2.10 (0.38)	1.89 (0.23)	0.109
Rt. RA con	G1	1.42 (0.22)	1.63 (0.28)	0.180	Rt. G max con	G1	4.53 (0.00)	5.11 (0.33)	0.180
	G2	1.45 (0.28)	1.63 (0.18)	0.593		G2	3.71 (1.41)	5.02 (0.61)	0.285
	G3	1.41 (0.21)	1.60 (0.35)	1.000		G3	4.24 (1.49)	4.84 (1.58)	0.109

Rt: Right, Con: contraction, TrA: Transverse abdominis, G max: Gluteus maximus

Table 3. Muscle strength

(N)		Pre (SD)	Post (SD)	p-value
Rt. Knee ext	G1	137.88 (56.59)	174.20 (80.75)	0.180
	G2	156.96 (85.69)	170.41 (68.08)	0.285
	G3	133.63 (71.15)	141.84(32.70)	1.000
Rt. Hip flex	G1	106.77 (27.25)	149.75 (2.10)	0.180
	G2	105.37 (4.29)	187.79 (62.79)	0.180
	G3	115.92 (39.20)	148.27 (47.52)	0.109
Rt. Hip ext	G1	76.67 (2.55)	134.92 (31.47)	0.180
	G2	74.09 (7.77)	154.18 (30.66)	0.109
	G3	108.89 (54.87)	168.03 (57.41)	0.109
Trunk felx	G1	54.12 (7.33)	91.93 (12.59)	0.180
	G2	74.74 (22.97)	85.01 (19.75)	0.109
	G3	78.38 (22.76)	89.38 (9.97)	0.285
Back ext	G1	65.98 (36.70)	110.47 (5.23)	0.180
	G2	89.60 (14.75)	106.26 (11.20)	0.180
	G3	69.53 (34.00)	100.32 (27.44)	0.285

Rt: Right, flex: flextion, ext: extension

Table 4. Trunk Flexibility

(°)	Group	Pre (SD)	Post (SD)	p-value
standing lordotic curve	G1	21.17 (4.01)	33.50 (2.59)	0.180
	G2	28.67 (2.85)	24.56 (7.46)	0.593
	G3	29.89 (20.16)	30.56 (7.60)	1.000
Lumbar flex ROM	G1	47.00 (1.41)	62.67 (4.71)	0.180
	G2	55.00 (5.20)	60.89 (2.27)	0.109
	G3	46.89 (22.24)	65.78 (9.13)	0.109
Lumbar ext ROM	G1	7.50 (7.50)	11.00 (0.00)	0.180
	G2	15.33 (2.00)	13.33 (4.36)	0.414
	G3	22.44 (14.93)	15.56 (2.52)	0.593

flex: flextion, ext: extension, ROM: range of motion

Table 5. Spatio-temporal parameters

		Pre (SD)	Post (SD)	p-value
Speed (m/s)	G1	1.09 (0.06)	1.08 (0.07)	0.317
	G2	1.20 (0.13)	1.23 (0.06)	0.593
	G3	1.05 (0.07)	1.06 (0.04)	0.593
Stride length (m)	G1	1.14 (0.05)	1.19 (0.02)	0.317
	G2	1.21 (0.08)	1.25 (0.08)	0.593
	G3	1.01 (0.08)	1.06 (0.10)	0.102
Single support (%)	G1	37.55 (0.92)	36.48 (0.53)	0.180
	G2	38.38 (2.29)	38.47 (1.92)	0.276
	G3	38.27 (1.48)	37.78 (1.63)	0.593
Pelvic tilt range (°)	G1	4.30 (0.35)	3.80 (0.92)	0.655
	G2	5.23 (0.36)	5.80 (2.57)	0.593
	G3	3.15 (0.99)	4.25 (1.00)	0.109
Pelvic obliquity range (°)	G1	10.30 (1.48)	8.95 (0.49)	0.180
	G2	12.65 (1.18)	12.05 (2.23)	0593
	G3	7.23 (1.27)	8.10 (1.73)	0.109
Pelvic rotation range (°)	G1	11.25 (6.79)	10.58 (0.67)	0.655
	G2	15.28 (3.68)	10.80 (1.41)	0.285
	G3	11.42 (4.84)	11.07 (5.80)	0.285

developed specifically for postpartum recovery, consisted of four stages. In the initial phase, visual feedback was provided using RUSI to effectively activate the TrA muscles.

All three groups exhibited a decrease in IRD, particularly Group 1, which showed a reduction at all four points. The utilization of RUSI likely facilitated accurate TrA muscles contraction in Group 1. When comparing the relaxation thickness of the RA muscle, Group 1 increased from 0.22mm to 0.29mm, whereas Group 2 slightly decreased from 0.32mm to 0.31mm. Conversely, during contraction, Group 1 increased from 0.43mm to 0.54mm, while Group 2 decreased from 0.57mm to 0.55mm. This result was due to the

Table 6. Body composition

		Pre (SD)	Post (SD)	p-value
Weight (kg)	G1	59.65 (6.43)	58.45 (7.28)	0.180
	G2	62.47 (12.22)	58.87 (9.85)	0.109
	G3	66.73 (8.14)	70.80 (8.24)	0.285
BMI (kg/m²)	G1	22.50 (2.83)	22.00 (3.11)	0.180
	G2	24.03 (4.18)	22.60 (3.22)	0.109
	G3	26.23 (1.66)	27.83 (1.72)	0.285
Abdominal fat percentage (%)	G1	0.87 (0.00)	0.86 (0.02)	0.317
	G2	0.86 (0.05)	0.86 (0.04)	0.180
	G3	0.91 (0.05)	0.94 (0.05)	0.285

BMI: body mass index.

5R system's emphasis on educating about proper ADIM and repetitive TrA muscles contraction[25].

Additionally, there was an increase in the relaxed thickness of the Quadriceps muscle from 2.21mm to 2.81mm in Group 1 but a slight decrease from 2.77mm to 2.72mm in Group 2. During contraction, Group 1 increased from 2.89mm to 3.44mm, while Group 2 slightly increased from 3.31mm to 3.33mm. This is attributed to Group 1's engagement in exercises within the 5R system, focusing on activities like squats and lunges with a weight 1kg heavier than a baby's weight, emphasizing the extensibility and contraction of the Quadriceps.

Furthermore, unlike the other groups, Group 1 exhibited an increase in muscle thickness during both relaxation and contraction of the gluteus maximus. This can be attributed to the hip-hinge exercises in the 5R system, leading to proper utilization of the hip joint through gluteus maximus activation, potentially reducing lumbar movements, effectively using the hip joint, and preventing lower back pain[26].Group 3, overall, showed an increase in most muscle thicknesses, possibly due to the natural increase in muscle mass associated with the group's weight gain[27].

The influence of a specific exercise program on muscle strength was assessed across three distinct groups. Overall, an increase in muscle strength was observed in most groupswithout statistical significance (P>0.05). The increase in core muscle strength, the central part of our body, indicates the potential benefits in enhancing spinal stability and maintaining proper posture in daily activities. Furthermore, a reinforced core augments efficiency in performing activities by providing support to the back and enhancing balance while executing movements. However, the lack of statistical significance suggests the need for further investigation due to limited sample sizes and potential variations in individual or intergroup responses.

In the evaluation of trunk flexibility among the three groups, diverse outcomes were observed based on exercise engagement and differences in exercise programs. Specifically, concerning the standing lordotic curve, Group 1 demonstrated a substantial increase from 21.17° (SD 4.01) to 33.50° (SD 2.59) post-exercise. Conversely, Groups 2 and 3 showcased a tendency towards reduction. Furthermore, the lumbar flexion angle increased from 47.00° to 62.67° in Group 1, slightly increased from 55.00° to 60.89° in Group 2, and notably increased from 46.89° to 65.78° in Group 3. The lumbar extension angle similarly increased in Group 1 from 7.50° to 11.00° but decreased in Groups 2 and 3. While these changes were observable, they did not reach statistically significant levels. 5R system performed by Group 1 included activities aimed at activating the iliopsoas muscle, a skeletal muscle that attaches from the lumbar vertebrae and the iliac fossa to the lesser trochanter of the femur. This muscle contributes to movements involving the lumbar spine, pelvis, and hip joint. Specifically, it influences hip flexion actions and contributes to pelvic anterior tilt and posterior tilt, thereby aiding in stabilizing the spine, pelvis, and maintaining vertical stability of the lumbar spine[28]. Therefore, the observed increase in the lumbar lordosis angle in Group 1 not only suggests an increase in lumbar lordosis but also indicates enhanced control of trunk flexion and extension angles due to improved control of the iliopsoas muscle.

The investigation into spatio-temporal parameters across the three groups revealed diverse outcomes before and after the exercise interventions. The analysis encompassed speed, stride length, single support, pelvic tilt range, pelvic obliquity range, and pelvic rotation range. Speed metrics showed marginal changes across all groups, while similarly, stride length exhibited minimal increases in all three groups. The percentage of single support decreased in Groups 1 and 3, while Group 2 displayed a slight postexercise increase. However, none of these changes reached statistical significance ($p > 0.05$). The ranges of pelvic tilt, obliquity, and rotation demonstrated various alterations within each group. However, these changes did not reach statistical significance ($p > 0.05$). While these observations indicate specific alterations in spatio-temporal parameters following the exercise programs, the lack of statistical significance suggests a need for further investigation, potentially utilizing larger sample sizes or more targeted assessments to elucidate significant changes.

The examination of body composition parametersillustrates certain trends following the exercise interventions. Regarding weight changes, Group 1 and Group 2 showcased a reduction in weight, although statistically insignificant. Conversely, Group 3 exhibited a slight increase in weight, similarly without statistical significance. These observations might indicate a tendency toward weight reduction in Groups 1 and 2, contrasting with an increase in Group 3, yet the differences did not reach statistical significance ($p > 0.05$). BMI alterations displayed analogous patterns. Only Group 1 showed a slight decrease in abdominal fat percentage. Notably, attention is warranted toward the weight gain in Group 3, where participants did not engage in exercise but continued their regular daily activities. During pregnancy, weight gain occurs due to increased fetal and placental weight, heightened blood volume in the mother, and an increment in body fat and protein[29]. Postpartum, weight loss transpires naturally as the placenta, fetus, and excess fluids are expelled, reducing edema. However, diminished physical activity during pregnancy and subsequently after childbirth, coupled with decreased stamina, diverse postpartum discomforts, and reduced physical activity due to childcare responsibilities, can significantly lower overall activity levels. Moreover, an imbalance in nutrient intake due to parenting demands might lead to an increased calorie intake compared to expenditure, potentially resulting in weight gain.

Conclusion

The study compared two exercise programs impact on postpartum women's recovery, focusing on various parameters. Group 1 following the 5R system showed significant reductions in Inter-Recti Distance, emphasizing RA muscle recovery. Muscle strength improved in knee and trunk movements across all groups post-exercise, but without statistical significance. Group 1 notably improved lumbar lordosis, possibly due to iliopsoas activation. While changes lacked statistical significance, exercise interventions, especially the 5R system, indicated positive trends in postpartum recovery. Larger studies are needed to confirm these findings and validate specific exercise programs in postpartum rehabilitation.

Conflict of Interest

The authors declare no conflicts of interest regarding the authorship and/or publication of this article.

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